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Imaging spectroscopy to assess the composition of ice surface materials and their impact on glacier mass balance

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The ice-albedo feedback plays a crucial role in various glaciological processes, but especially influences ice melt. Glacier surface albedo is one of the most important variables in the energy balance of snow and ice, but depends in a complicated way on many factors, such as cryoconite concentration, impurities due to mineral dust, soot or organic matter, grain size or ice surface morphology. Our understanding on how these various factors influence glacier albedo is still limited hindering a spatially and temporally explicit parameterization of energy balance models and requiring strongly simplified assumptions on actual albedo values.

Over the last two decades, several studies have focused on glacier surface albedo using automatic in-situ weather stations in combination with radiation measurement setups or satellite images. Due to limitations of both approaches in matching either the spatial or the temporal length scale of glacier albedo, still fairly little is known about the state, changes and impact of glacier surface albedo in the Swiss Alps, although there are obvious changes in surface characteristics on most alpine glaciers over the last years.

With use of the APEX (Airborne Prism EXperiment) image spectrometer, measurements of reflected radiation were acquired in high spatial and spectral resolution on Glacier de la Plaine Morte, Switzerland, to explicitly analyse the ice surface. In-situ radiometric measurements were acquired with an ASD field spectrometer in parallel to APEX overflights. These data are intended to be used for validation purposes as well as input data for the linear spectral unmixing analysis of the APEX data. Seasonal glacier mass balance is monitored since five years using the direct glaciological method.

This contribution presents a first evaluation of the data collected in summer 2013. The obtained in-situ and airborne reflectance measurements were used in combination with a spectral mixture analysis (SMA) approach to assess the composition and spatial distribution of cryoconite and impurities on the surface of Glacier de la Plaine Morte. Spectral properties of five different endmembers (bright ice, old snow, clear water, brown-grey and black supraglacial material) were determined in-situ and their abundances and distribution across the entire glacier surface were evaluated by means of an SMA approach that was applied to the image data. Results provide important information to improve the understanding of the spatial distribution of glacier ablation, which appears to be strongly dependent on surface albedo.